IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	NEWELL et al.
Serial No.:	10/028,791
Filed:	28-12-2001
Title:	ATM OVER MPLS CONNECTION ESTABLISHMENT MECHANISM
Group:	2666
Examiner:	AHMED, SALMAN
Attorney Ref.:	PAT 2169-2

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DECLARATION UNDER 37 CFR §1.131

The undersigned, Darren L. Newell, Sandra S. Ballarte, and Kasper K. Reinink, hereby declare on information and belief:

1) We are the coinventors of claims 1 through 20 of the above-identified patent application.

2) Prior to December 19, 2000, we conceived the idea of a connection mechanism for using ATM over MPLS as described and claimed in our application.

3) During at least December 19, 2000 through March 28, 2001, we prepared a standards proposal (a copy attached hereto as Exhibit A) for submission to an ATM standards body that was scheduled for public disclosure in April 2001.

4) Several items including the standards proposal (Exhibit A) and a technical document (a copy attached as Exhibit B and dated as "processed 2000-12-13") including a section containing the details of how ATM on-demand connections are established over an MPLS network, and therefore describing our invention, were provided to the in-house patent department of the Assignee on or before March 28, 2001.

5) On March 28, 2001, the Assignee's in-house patent department received our invention submission (redacted copy attached hereto as Exhibit C), which included as attachments at least Exhibits A and B.

6) On March 29, 2001, the Assignee's in-house patent department filed a provisional patent application based upon at our invention submission and related attachments mentioned above. Such provisional patent application forms the priority for the above-identified patent application.

7) We hereby declare that all statements made herein of our own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 USC 1001 and that such willful false statements may jeopardize the validity of the instant application or any patent issued thereon.

Darren L. Newell — Sept. 13, 2005
Date

Sandra S. Ballarte — Sept. 13, 2005
Date

Kasper K. Reinink — 13 SEPT 2005
Date

Declared before me on the 13th day of September, 2005, at Ottawa, Ontario, Canada.

Jeffrey M. Measures
A Notary Public for the Province of Ontario
My commission is indefinite.

IP-OTT-1\812659\1

ATM Forum Technical Committee
AIC, CS

Contribution

Title: **PNNI for ATM over MPLS**

Date: 22-27 April 2001

Location: Amsterdam, Netherlands

Source: **Nortel Networks**

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Abstract: MPLS has the potential to consolidate service provider networks and services, in particular ATM, over a single common core infrastructure. The salient aspects of the reference model for ATM over MPLS consist of ATM-MPLS interworking units attached to an MPLS network. Between the interworking units PNNI can be used as the control protocol to establish MPLS label switched paths that the interworking units map to corresponding ATM connections.

Notice

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1 Introduction

MPLS has the potential to consolidate service provider networks and services, in particular ATM, over a single common core infrastructure. At the last two meetings of the ATM Forum, the AIC group agreed to produce a specification for ATM services over MPLS. One aspects of this work is to define an MPLS protocol to encapsulate ATM cells and AAL 5 protocol data units as discussed in the companion contribution [1].

The purpose of this contribution is to discuss the use of PNNI as the control protocol for providing ATM services over MPLS. The contribution is structured as follows: Section 2 presents the architecture and the transport requirements for multi-service, including ATM services, over MPLS. Section 3 describes the role of PNNI over MPLS networks. Section 4 discusses the use of PNNI signalling to establish MPLS label switched paths between ATM-MPLS interworking units. Finally, Section 5 proposes protocol stacks for transporting PNNI messages over MPLS networks.

2 Architecture and requirements

2.1 ATM-MPLS Reference Model

ATM over MPLS reference model is shown in Figure 1. ATM-MPLS interworking units (IWG units) are attached to an MPLS network. MPLS label switched paths (LSPs) called "transport LSPs" connect a pair of IWG units. One of the IWG units is the source of data flowing in a transport LSP and the other the sink. Several "Interworking LSPs" (I-LSPs) can be nested inside one transport LSP. Each I-LSP corresponds to an ATM virtual path connection (VPC) or virtual channel connection (VCC). One of the main roles of an ATM-MPLS IWG unit is to map MPLS I-LSPs to the corresponding ATM connections and vice versa.

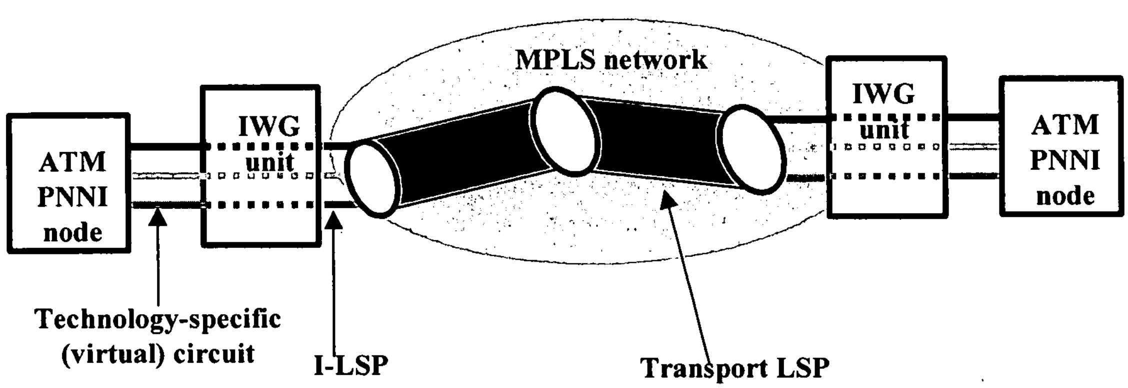


Figure 1 - Reference model

2.2 Data Transfer protocol stacks

The MPLS side of an IWG unit consists of the following protocol layers: Above the physical layer runs a link layer protocol, for example PPP over Sonet/SDH as defined in

RFC 2615 [2]. Above the link layer there is MPLS label stack processing defined in RFC 3032 [3]. Between two IWG units the "Multi-service over MPLS" (MS/MPLS) protocol runs. The ATM Forum AIC group currently is addressing the ATM aspects of this protocol.

The ATM side of an IWG unit consists of the physical and ATM layers. AAL 5 terminates at the IWG when AAL 5 PDUs will be transmitted over the MPLS network rather than ATM cells. More details on the transport methods over MPLS can be found in [1].

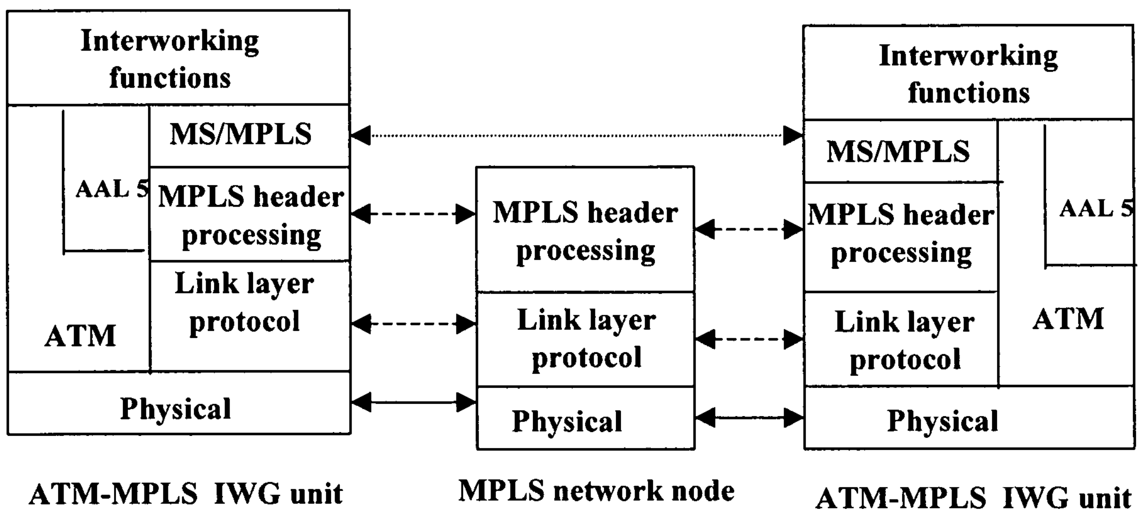


Figure 2 – Data transfer protocol stacks

2.3 Multi-service over MPLS frame format

The frame format for Multi-service over MPLS (MS/MPLS) is shown in Figure 3. It consists of the link layer protocol header followed by MPLS label stack defined in [3] and MS/MPLS service specific header. MS/MPLS specific header is a variable length header specific to a technology (for example, ATM or frame relay). ATM over MPLS specific header is defined in [1]. The payload field contains user or network data.

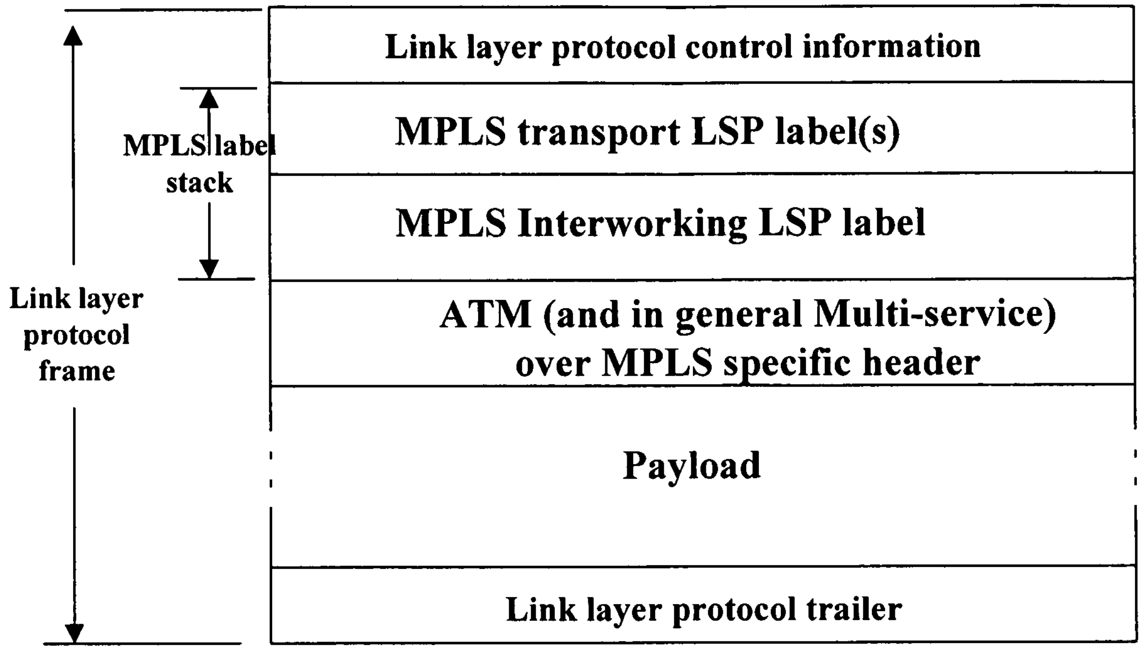


Figure 3 – Multi-service over MPLS frame format

2.4 ATM over MPLS transport requirements and transport modes

The contribution on ATM encapsulation over MPLS [1] identifies the following ATM over MPLS transport requirements:

1. Support of ATM Virtual path and virtual channel connections (VPC and VCC)
2. Support all AAL types and cell types (user and OAM cells)
3. Support of existing ATM traffic and QoS capabilities
4. Ability to transport a single cell in a MS/MPLS frame
5. Ability to transport concatenated cells in a MS/MPLS frame
6. Ability to transport a complete or fragmented AAL 5 frames in a MS/MPLS frame

Transport of a single cell encapsulated in a MS/MPLS frame is the only mandatory transport mode. Transport of AAL 5 PDUs and concatenated cells are optional transport modes.

3 PNNI over MPLS networks

3.1 Role of PNNI

From PNNI perspective, MPLS network and transport LSPs can be considered as an abstraction of a PNNI physical link established between two PNNI nodes. Figure 4 captures this view. In an ATM over MPLS environment, the role of PNNI routing protocols is the same as in a traditional ATM PNNI network. The role of PNNI signalling is to establish MPLS I-LSPs between IWG units during AM VCC or VPC establishment and to perform other signalling functions defined in PNNI specification. More on the signalling role of PNNI is addressed later in the contribution. The routing aspects of PNNI over MPLS network will be addressed in a future contribution

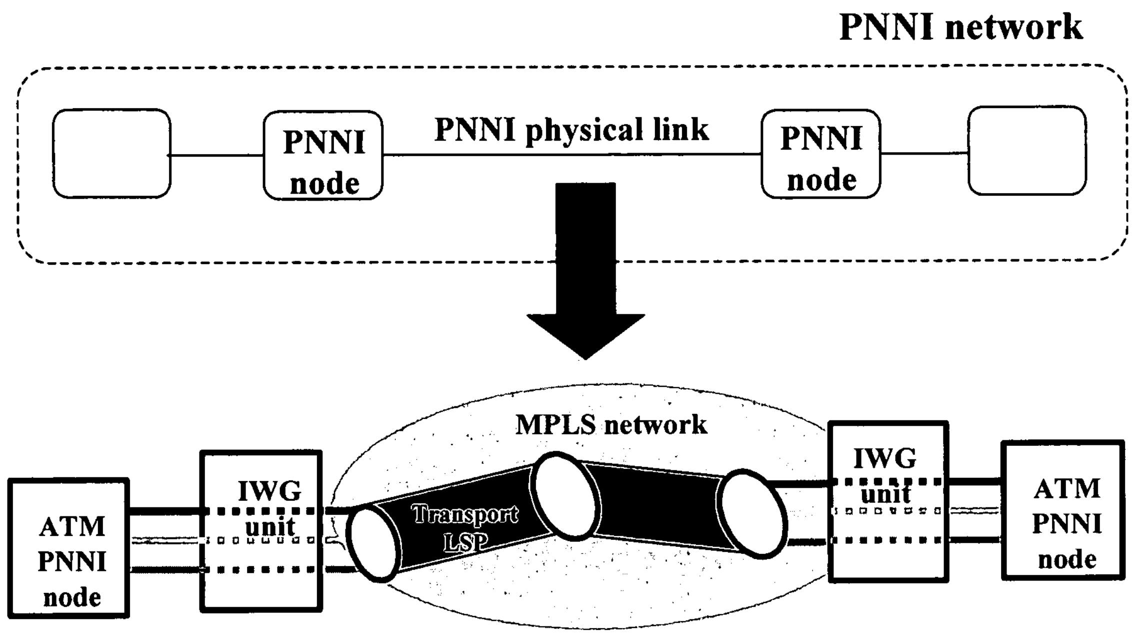


Figure 4 – PNNI over MPLS network

3.2 Relationship between ATM connection and MPLS LSP

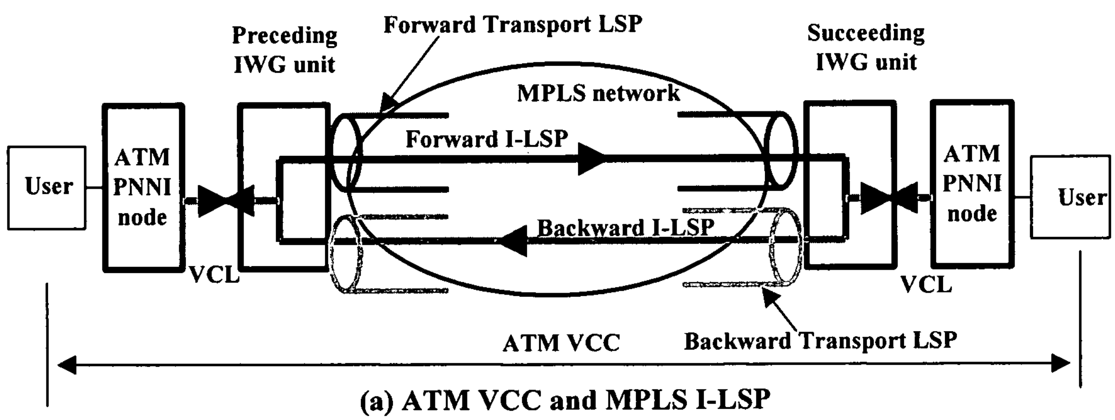
ATM connections (VPC and VCC) are usually considered to be bi-directional entities mainly because of the way they are created and identified. A single identifier (a VPI or a VCI respectively) refers to the two directions of a VPC or VCC and ATM signalling establishes the two directions simultaneously with the same signalling message flows. But in general each direction of a VPC or VCC may have different traffic and QoS characteristics and PNNI, from a resource management perspective, treats each direction separately and independently. MPLS LSPs, on the other hand, are uni-directional entities from different perspectives: Traffic and QoS engineering, data flow and from the way they are created and identified (labeled).

ATM over MPLS requires to "interwork" ATM VPC or VCC with MPLS LSP. An ATM VCC is a sequence of virtual channel links (VCL) and an ATM VPC is a sequence of virtual path links (VPL). During the creation of a VCC or VPC a pair of I-LSPs will have

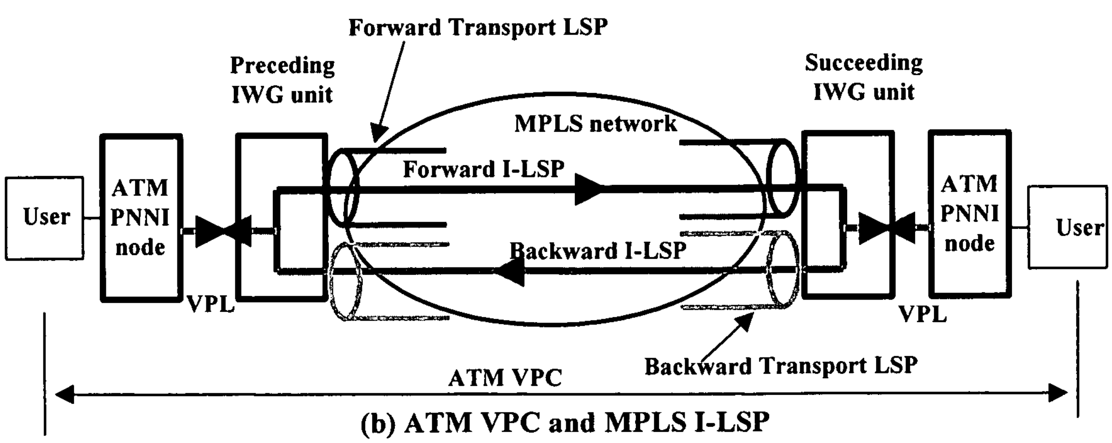
to be established between two IWG units. Each I-LSP will carry traffic in one direction only.

Each I-LSP is established in a different transport LSP such that the flow of data of an I-LSP is the same as the flow of data allowed in the corresponding Transport LSP. Note the pair of transport LSPs used to carry VCC or VPC traffic in opposite directions are establishment on the same physical interface.

Figure 5 illustrates the relationship between transport LSP,. I-LSP and ATM VCC or VPC. The terminology of PNNI signalling is adopted: The preceding IWG unit is the IWG unit initiating the establishment of an ATM VCC or VPC. The succeeding IWG unit is the IWG unit receiving a request to establish an ATM VCC or VPC. The forward (transport or interworking) LSP is the LSP carrying the traffic from the preceding IWG unit to the succeeding IWG units. The backward LSP is the LSP carrying the traffic in the opposite direction.



(a) ATM VCC and MPLS I-LSP



(b) ATM VPC and MPLS I-LSP

Figure 5 – ATM VCC and VPC and MPLS LSP

PNNI physical links have their own signalling and routing control channels. The default signalling channel is in VPI=0 and VCI=5 and the default routing control channel is in VPI=0 and VCI=18. Likewise each transport LSP used as a PNNI physical link will have its own nested LSP one for carrying PNNI signalling messages between two IWG units and the other for the routing messages. The signalling channel of a transport LSP is used to create I-LSP within the transport LSP. Figure 6 shows the different LSPs (I-LSP, signalling and routing LSP) nested in a pair of forward and backward transport LSPs.

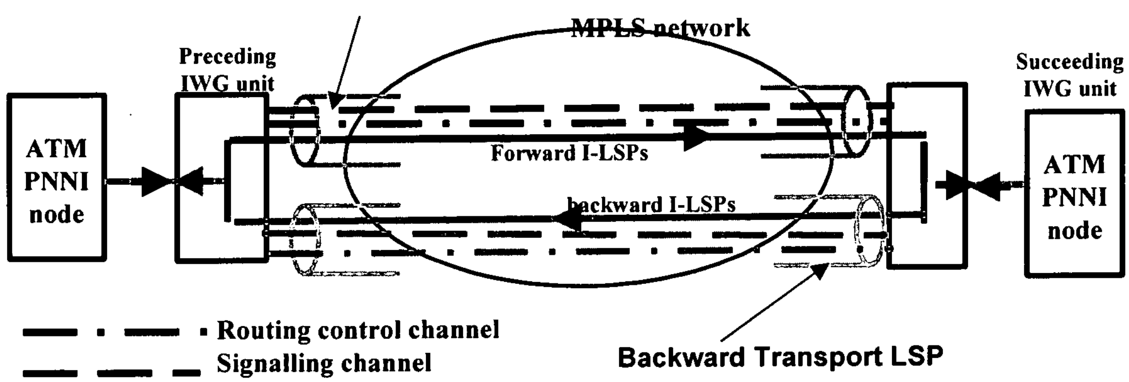


Figure 6 – Transport LSPs and their different nested LSPs

3.3 PNNI over MPLS specific requirements

PNNI Signalling over MPLS will be used for:

- Establishing I-LSPs between ATM-MPLS IWG units
- Transporting I-LSP labels between IWG-units
- Selecting the transport mode (single cell, concatenated cells, or AAL 5 frames)
- Negotiating of the maximum number of concatenated cells
- Negotiating of the presence of the VCI in ATM over MPLS specific header

PNNI routing aspects over MPLS networks will be addressed in a future contribution. Now it is sufficient to say that implementations will need to assign a PNNI port identifier for each transport LSP used as a PNNI physical link. PNNI port identifiers are used in different PNNI protocols.

4 PNNI signalling over MPLS network

4.1 Signalling of various parameters

Several new parameters have to be signalled between two IWG units during I-LSPs establishment. They are identified in the following subsections. Other parameters may be added in the future depending on the needs. For some of the parameters, negotiation procedures have to be defined. The details will be provided in a future contribution.

4.1.1 LSP label values and transport LSP local port identifier

The following LSP identifiers have to be exchanged between the two IWG units:

- Forward I-LSP label value
- Backward I-LSP label value
- Port identifier assigned to the backward transport LSP by the preceding IWG unit. The role of this identifier will become clear in the subsection on I-LSP establishment procedures.

4.1.2 Transport mode selection

The following transport modes are allowed (see [1] for details):

- Single cell transport: When this mode is selected a single user cell is encapsulated an ATM over MPLS frame. This transport mode is applicable to VCC and VPC and is the only mandatory transport mode to support by ATM-MPLS IWG units.

- Concatenated cell transport: When this mode is selected multiple user cells may be encapsulated in an ATM over MPLS frame. This transport mode is applicable to VCC and VPC.

- Complete re-assembled AAL 5 PDU: When this mode is selected a complete AAL 5 PDU consisting of the payload, Pad and control information will be encapsulated in an ATM over MPLS frame. This mode implies that an IWG unit will have to re-assemble cells belonging to an AAL 5 PDU.

- Segmented AAL 5 PDU transport: When this mode is selected an incomplete AAL 5 PDU may be encapsulated in an ATM over MPLS frame. There are at least two reasons to send incomplete AAL 5 PDUs: The first one is when an OAM cell is received and the second one is when an AAL 5 PDU is too long for transmission over the MPLS network.

The transport mode has to be selected between the two IWG units for each I-LSP. Only single cell transport mode is mandatory, the other modes are optional. Therefore negotiation procedure with fall back to single cell transport mode will have to be defined.

4.1.3 Presence of the VCI field

The presence of the VCI field in ATM over MPLS specific header has to be negotiated for each I-LSP. Several choices are possible (for example: VCI is always present or never present).

The different choices will be defined and details provided in a future contribution.

4.1.4 Maximum number of concatenated cells

With concatenated cell transport, there is a need to negotiate the maximum number of cells that can be encapsulated in an ATM over MPLS frame. This negotiation has to be done for each I-LSP.

Note AAL 5 PDU length can be obtained from the AAL information element.

4.1.5 Usefulness of PNNI information elements for I-LSP establishment

Most of PNNI information elements carried in the SETUP message provide important information about the characteristics and other attributes of the I-LSP to be established between the two ATM-MPLS IWG units:

- AAL parameters: This information element identifies the AAL protocol that will be used. In particular if it is AAL 5, the IWG units can determine whether to operate in AAL 5 frame transport mode or cell transport mode. In the case of AAL 5 this information element provides also the maximum length of AAL 5 frame payload.

- ABR additional parameters, ABR setup parameters, Alternative ATM traffic descriptor, ATM traffic descriptor, End-to-end transit delay, Extended QoS parameters, Minimum acceptable ATM traffic descriptor and QoS parameter: These information elements contain traffic and QoS characteristics of the ATM VCC or VPC to setup. The IWG units will have to use them to establish I-LSP with the right traffic and QoS characteristics.

- Broadband bearer capability: This information element identifies ATM traffic capability (for example: CBR or VBR) and whether the request is to establish a user VCC or VPC.

- Calling and called party soft PVPC and PVCC indicates that the connection is a soft PVPC or PVCC rather than SVC.

- Connection identifier: This information element includes the VCI to be optionally inserted in ATM over MPLS specific header. It provides also the VPI and information to the IWG units on associated vs. non-associated signalling.

4.2 Outline of I-LSP establishment procedures between two IWF units

1. After receiving a request from one of its preceding PNNI node to establish a VCC or VPC, a preceding IWG unit initiates the establishment of a pair of I-LSPs between itself and a succeeding IWG unit. Figure 7 shows PNNI signalling message flows for the reference model of Figure 6.

2. A preceding IWG unit initiates the establishment of a pair of I-LSPs by sending a SETUP message to a succeeding IWG unit and by following the procedures of PNNI Section 6.5.2.about call/connection establishment relevant to a preceding PNNI node. In addition to the mandatory and optional information elements required to establish an ATM connection, the SETUP message shall contain some of the new information identified in Section 4.1 necessary to establish the pair of I-LSPs between the two IWG units.

3. In the SETUP message, the preceding IWG unit shall contain the following additional information: The I-LSP backward label value and PNNI port identifier of the backward transport LSP to identify the transport LSP where the backward I-LSP will be established. In addition, it may provide other information such as the transport mode for each LSP, the presence of the VCI field and the maximum number of concatenated cells if it requests concatenated cell transport mode.

4. The selection by the preceding IWG of the backward transport LSP requires that it performs CAC on that LSP in order to ensure that sufficient resources are available to satisfy the traffic and QoS requirements of the VCC or VPC being established. The backward transport LSP corresponds in PNNI to the incoming direction of a link. The state of the incoming direction of a PNNI link is obtained periodically from the node at the other end of the link. Between two updates, the preceding IWG can keep track of the backward transport LSP resources consumed so far.

5. After receiving a SETUP message, the succeeding IWG unit follows the procedure of PNNI Section 6.5.2 applicable to a PNNI succeeding node. In addition, in the first positive reply message with global significance (ALERTING or CONNECT message) the succeeding IWG unit shall include the following new information: The forward I-LSP label value. In addition, it may provide other information such as the transport mode for each LSP, the presence of the VCI field and the maximum number of concatenated cells, if concatenated cell transport mode is selected. Negotiation procedures will be provided in a future contribution.

6. The pair of I-LSPs are established between the two IWG units after the preceding IWG unit has received a CONNECT message from the succeeding IWG unit.

7. The signalling messages sent by the preceding IWG unit are carried in the signalling LSP of the forward transport LSP. Similarly, the signalling messages sent by the succeeding IWG unit are carried in the signalling LSP of the backward transport LSP. The call reference encoded in PNNI signalling messages allows the IWG units to correlate, as belonging to the same call, the various messages sent and received in the backward and forward transport LSPs.

8. To establish a parallel with MPLS architecture defined in RFC 3031 [4], the label assignment for the forward I-LSP corresponds to "downstream-on-demand" assignment" where the downstream label switching router (LSR) is the succeeding IWG unit. The preceding IWG unit corresponds to an upstream LSR requesting a label from the downstream LSR/succeeding IWG unit. For the forward I-LSP the

preceding IWG unit corresponds to the Ru LSR and the succeeding IWG unit to the Rd used in [4].

9. For the backward path the label assignment method roughly corresponds to "unsolicited downstream" label distribution of [4] since the succeeding IWG unit has not requested explicitly a label from the preceding IWG unit. The choice of this allocation method is caused by the way PNNI signalling establishes the two directions of a VCC or VPC and the need to avoid sending separate SETUP messages for each I-LSP. For the backward I-LSP, the succeeding IWG unit corresponds to an upstream or Ru LSR and the preceding IWG unit to a downstream or Ru LSR.

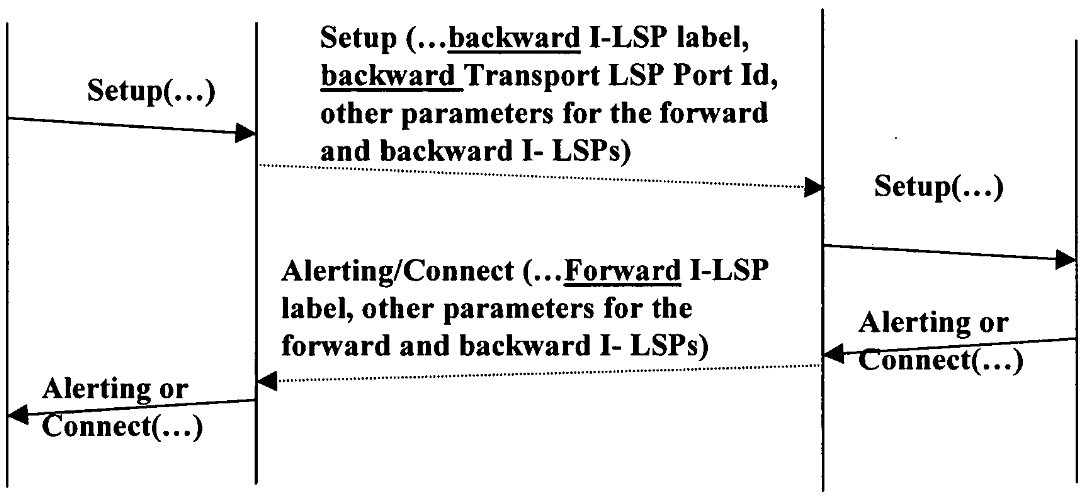


Figure 7 – Forward and backward I-LSPs establishment

4.3 Carriage of LSP parameters

PNNI Generic Application Transport (GAT) capability is a suitable mechanism to transport PNNI information required to establish I-LSPs between two IWG units. GAT information element may be included in the SETUP, ALERTING and CONNECT message. GAT procedures specific to ATM over MPLS will have to be defined.

GAT information element is shown in Figure 8. The required enhancements to the GAT IE are as follows: A new application type (octet 5) and Application-specific information (octet 6 to 512) have to be defined.

	Octet
PNNI GAT information elements first four octets	**1 to 4**
Application type **New type: 0000 0101 (ATM over MPLS)**	**5**
Application-specific information ***Carriage of the forward and backward I-LSP labels and other parameters that need to be exchanged between the two interworking units***	**6 to 512**

Figure 8 – Enhancements to GAT information element

For ATM over MPLS GAT IE application-specific field will carry the different parameters discussed in subsection 4.1. A general layout is shown in Figure 9. The details will be provided in a future contribution.

I-LSP forward or backward label value	**Octets 6 to 512 of GAT IE**
Forward I-LSP Parameters	
Backward I-LSP Parameters	

Figure 9 – GAT IE application-specific field

5 Transport of PNNI messages

Figure 10 shows PNNI protocol stacks over ATM and the proposed stacks for PNNI over MPLS. As shown in Figure 10 (b) above the physical layer, the link layer protocol and MPLS label stack processing appear followed by the protocol for ATM encapsulation over MPLS with frame transport only.

It is proposed to keep SSCF at the UNI and SSCOP for PNNI signalling protocol and to have PNNI routing protocols run above ATM encapsulation over MPLS protocol defined in [1] with frame transport. There is no need to use AAL 5 for PNNI transport over MPLS.

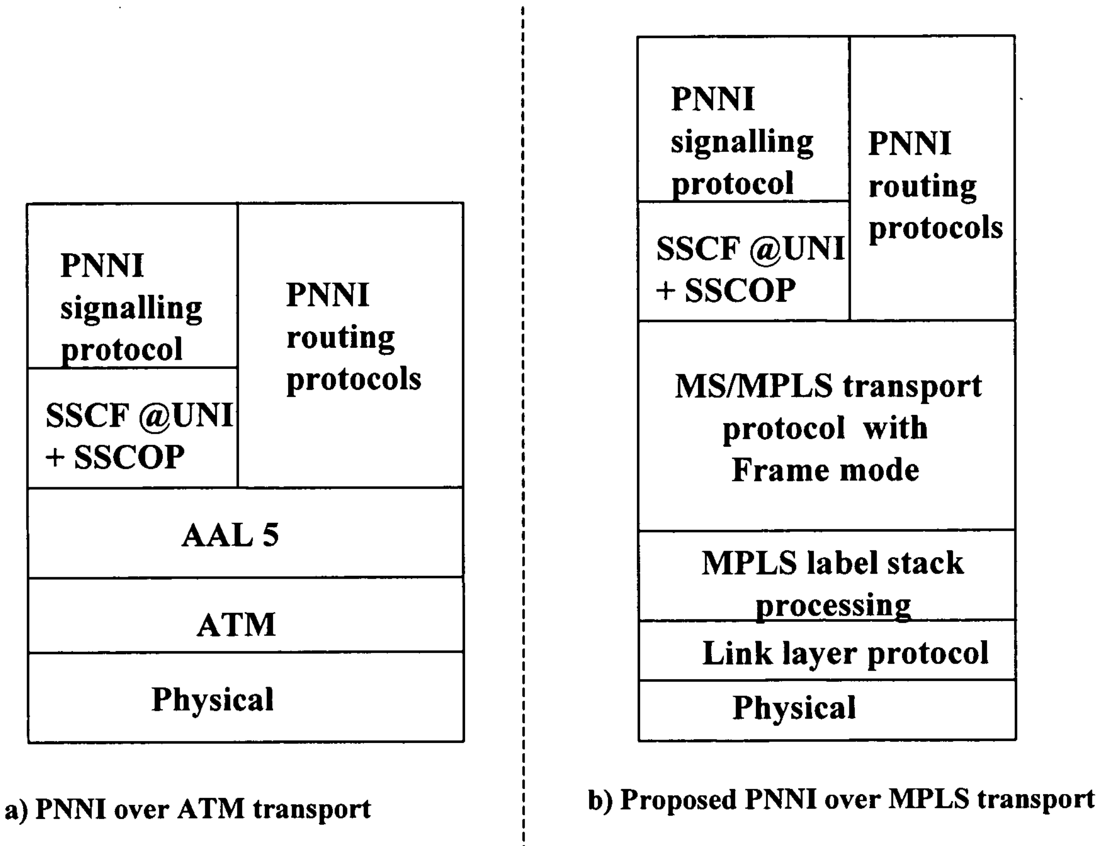


Figure 10 – PNNI protocol stacks

The frame format for PNNI message encapsulation in ATM over MPLS frames is shown in Figure 11. It is proposed to use the header format for AAL 5 PDU transport defined in [1] but without using the rightmost two bits assigned to CLP and EFCI and be setting them to 0.

MPLS Interworking LSP label (4 octets)						
RES	VCIP *yes/no*	Mode *frame*	RES	FRAG	0	0
VCI (optional)						
Payload = PNNI complete or segmented message						

Figure 11 – Frame format for PNNI messages

6 Motion

It is proposed to initiate work on PNNI for ATM services over MPLS networks based on Sections 2, 3, 4 and 5 of this contribution.

7 References

[1] ATM_Forum/01-0005, User plane encapsulation for ATM/MPLS network interworking, March 2001, in directory /atm/documents/2001/01-04/aic.

[2] RFC 2615 PPP over SONET/SDH, June 1999.

[3] RFC 3032 MPLS Label Stack encoding, January 2001.

[4] RFC 3031 MPLS Architecture, January 2001.

[5] AF-CS-0126.000, PNNI Addendum for Generic Application Transport, version 1.0, July 1999.

NORTEL NETWORKS

CDN Passport MS3/CE ATM Networking

SD

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Authors: Andrew Laverance

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Abstract

This is the System Description for the CDN Passport MS3/CE ATM Networking feature.

Summary of Amendments

Changes in Version 01.01 (by: Andrew Laverance):

- Original version of the document.

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1 SD Tracking

1.1 SD Entrance Criteria

BEFORE starting Detail Design, ensure that:	Yes	No	N/A
FS is available to all developers who need it when applicable	X		
Functionality/Interface input from other related features is available		X	

1.2 SD Exit Criteria

BEFORE declaring Detail Design done, ensure that:	Yes	No	N/A
Detail design covers all functionality outlined in the FS			
SD was reviewed with key developers			
Project Plan was revised and updated			
SD was updated from the review and released			
SD review minutes and closed action items are filed			

2 Introduction

This document describes the detailed design for the CDN Passport MS3/CE ATM Networking feature.

2.1 Terminology

ATM: Asynchronous Transfer Mode. ATM is a technology that provides access to a network by multiplexing user information into fixed-length units called cells. ATM forms the basis for broadband networks.

ATM virtual link: Refers to a link from one ATM node to another in an ATM topology.

CoS: Class of Service

CPE: Customer Premises Equipment

DPRS:Dynamic Packet Routing System. DPRS is a connectionless routing system for delay-sensitive and high-throughput variable bit rate traffic. DPRS carries data traffic such as frame relay and all DPN-100 services such as X.25.

DTL: Designated Transit List. A list of node and link identifiers that completely specify a path across a single PNNI peer group. Link identifiers are optional.

FP: Function Processor. An FP is a type of processor card that supports physical interface connections to subscriber lines and network trunks. It is optimized to support the software that performs the real-time functions associated with the forwarding and routing of frames. Different types of FPs support different types of physical interfaces, such as DS1, E1, V.35, and V.11 access and trunks.

IISP: Interim Inter-Switch Signaling Protocol. ISP provides interconnection between Passport switches as well as interconnection between Passport and non-Passport switches (Nortel Networks- family switches and switches from other vendors).

IP: Internet Protocol. IP is a protocol suite operating within the Internet as defined by the requests for comment (RFC). This may also refer to the network-layer (level 3) of this protocol stack; the layer concerned with routing datagrams from network to network.

LSP: Label Switched Path

L-LSP: Label inferred Label Switched Path

MPLS: Multi Protocol Label Switching.MPLS is a label-swapping, networking technology that forwards packet traffic over multiple, underlying layer-2 media. This technology integrates layer-2 switching and layer-3 routing by linking the layer-2 infrastructure with layer-3 routing characteristics. Layer-3 routing occurs at the edge of the network, and layer-2 switching takes over in the MPLS network core.

MPLS Domain: A contiguous set of nodes which operate MPLS routing and forwarding and which are also in one Routing or Administrative Domain.

MPLS transport media: Refers to Label Switched Paths across an MPLS Domain which carry data from one end to the other.

OPC: Optera Packet Core. Optera Packet Core. OPC is an IP router and MPLS core switching system operating in the TeraBits range. It is a central part of Nortel Networks' Unified Networks solution known as OPS (Optera Packet Solution). OPC provides a high-speed optical back bone, and it is aimed at a service provider and carrier market.

Overlay model: A means of transporting one protocol over another where the two protocols use separate address, topology and connection management.

PNNI: Private Network to Network Interface. PNNI is an ATM routing and signaling protocol that permits dynamic routing and networking.

POS: Packet Over Sonet

PPP: Point to Point Protocol

QoS: Quality of Service. QoS is a series of service classes that reflect the traffic importance and urgency over a connection. For ATM networks and services, QOS classes are defined by the ATM Forum for UNI 3.0/3.1 (numerical designations 0 through 4) and for UNI 4.0 (UBR, CBR, rtVBR, nrtVBR) which have direct correspondence. Passport also defines a set of corresponding ATM QOS classes (UBR, CBR, VBR, CO, CNLS). For IP traffic over the VNS outbound media, Qos is defined at the inbound protocol port level, and implemented by VNS.

Topology: The geometric physical or electrical configuration describing a local communication network --- the shape or arrangement of the system.

Tunnel: A secure, virtual point-to-point link that connects two points and transfers data from one point to the other. This data is not modified by the intervening nodes.

UNI: User Network Interface. UNI can either be the frame relay service is provided through a standard interface between the user device and the network, or an interface between ATM user equipment and ATM network equipment.

VCC: Virtual Channel Connection. VCC is a concatenation of virtual channel links that extends between two points where the ATM adaptation layer is accessed.

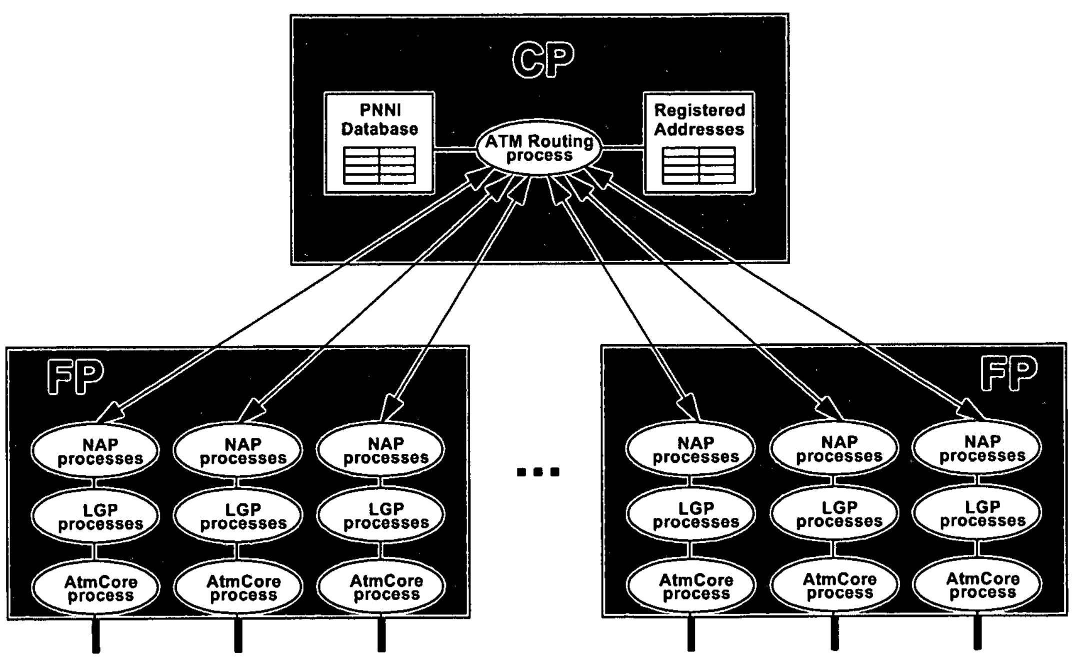
VC: Virtual Circuit. A VC is a connection between two devices that acts as though it's a direct connection even though it may physically be circuitous. The term is used most frequently to describe connections between two hosts in a packet-switching network. In this case, the two hosts can communicate as though they have a dedicated connection even though the packets might actually travel very different routes before arriving at their destination. An X.25 connection is an example of a virtual circuit. VCs can be either permanent (called PVCs) or temporary (called SVCs).

VP: Virtual Path. In frame relay, a VP is the equivalent of a physical connection to a destination address using shared facilities. VPs can be permanent (PVP) or switched (SVP). The VP is anchored in the function processors that are connected to the end user devices. In ATM networking, a VP is a unidirectional transport of ATM cells belonging to virtual channels that are associated by a common identifier value called VPI.

2.2 System overview

ATM networking consists of a centralized ATM routing process on the CP and ATM Logical Port and Networking API processes on the FPs. Each ATM signaling instance maintains both a Logical Port process and a Networking API process. This overall system architecture is unchanged by the introduction of ATM Networking over MPLS and is illustrated in Figure 1. For a complete description of the ATM Networking, please refer to **[1] MD-1997.0324, "Passport ATM Networking Phase-2", SD, Darren Newell et al, July 1999, Nortel Networks.**. However, enhancements to LGP and ATM Core are required for ATM Networking over MPLS.

Figure 1 High Level Architecture



In order to support ATM Networking over MPLS:

- ATM Core is enhanced to provide:
  a. provide a new functional API interface to allow the passing of MPLS label data to and from ATM networking
- LGP is enhanced to:
  a. store MPLS label data provided by ATM core
  b. store MPLS label data received in the GIT IE of a SETUP or CONNECT PDU
  c. interface with ATM Core to pass and receive MPLS label data
  d. support a new MPLS label identifier GIT information element.

2.2.1 Design Strategy and Objectives

The following three development considerations were the main objectives in the Passport implementation of ATM Networking over MPLS:

- ensure that ATM Networking does not need to have any detailed knowledge of the MPLS data information being passed to and from ATM Core. In fact, from an ATM Networking point of view, this data need not even be MPLS related.
- not require any code specific for IISP or PNNI. Keep the code as simple and generic as possible.
- robustness and extensibility to subsequent ATM Networking over MPLS feature development.

3 Overall description

3.1 Generic Identifier Transport Information Element

Figure 2 GIT Information Element Format describes the format of the GIT IE containing the MPLS service label data which will be contained within the SETUP and CONNECT PDUs. This is described in more detail in **[2] MD-2000.0422, "CDN Passport MS3/Capacity Evolution ATM Networking", FS, Andrew Laverance et al, Oct 2000,Nortel Networks.**.

Figure 2 GIT Information Element Format

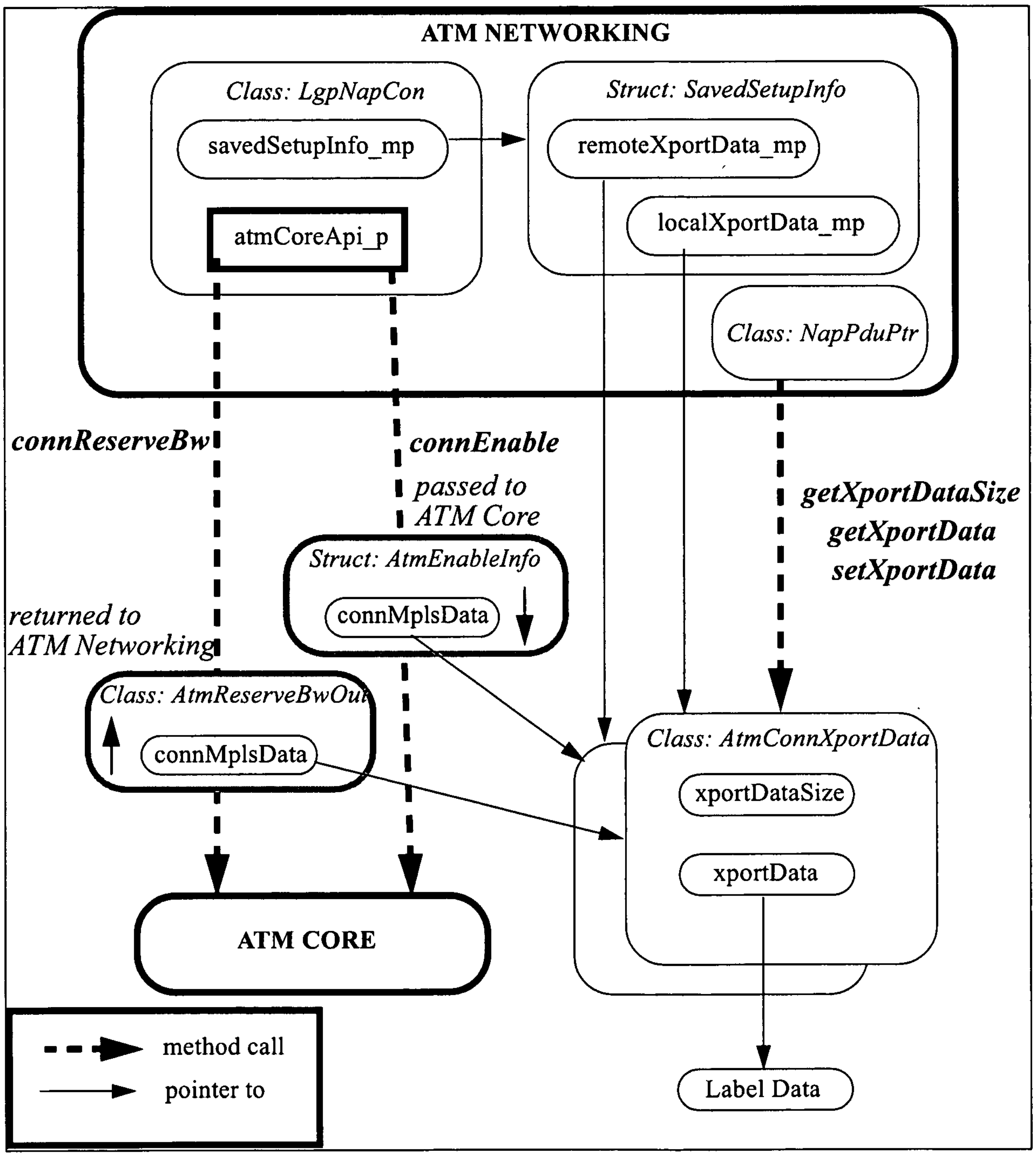
<table>
<tr><th colspan="8">Bits</th><th></th></tr>
<tr><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>Octet(s)</th></tr>
<tr><td colspan="8">Generic identifier transport information element</td><td rowspan="3">1</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td colspan="8">Information element identifier</td></tr>
<tr><td>1</td><td colspan="2">Coding</td><td colspan="5">Information Element Instruction Field</td><td rowspan="2">2</td></tr>
<tr><td>Ext</td><td colspan="2">Standard</td><td>Flag</td><td>Reserv</td><td colspan="3">Information Element Action Ind</td></tr>
<tr><td colspan="8">Length of Generic identifier transport information element contents</td><td>3</td></tr>
<tr><td colspan="8">Length of Generic identifier transport information element contents (continued)</td><td>4</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>1</td><td rowspan="2">5</td></tr>
<tr><td colspan="8">Identifier Related Standard/Applications (Vendor Specific)</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td><td>1</td><td rowspan="2">6</td></tr>
<tr><td colspan="8">Identifier Type (Transport identifier)</td></tr>
<tr><td colspan="8">Identifier Length</td><td>6.1</td></tr>
<tr><td colspan="8">Identifier Value</td><td>6.2
to
6.m</td></tr>
<tr><td colspan="8">Identifier Type</td><td>N</td></tr>
<tr><td colspan="8">Identifier Length</td><td>N.1</td></tr>
<tr><td colspan="8">Identifier Value</td><td>N.2
to
N.m</td></tr>
</table>

3.2 System architecture

3.2.1 ATM Core Interface

Figure 3 on page 16 describes the interface between ATM networking and ATM core in terms of interaction between data types.

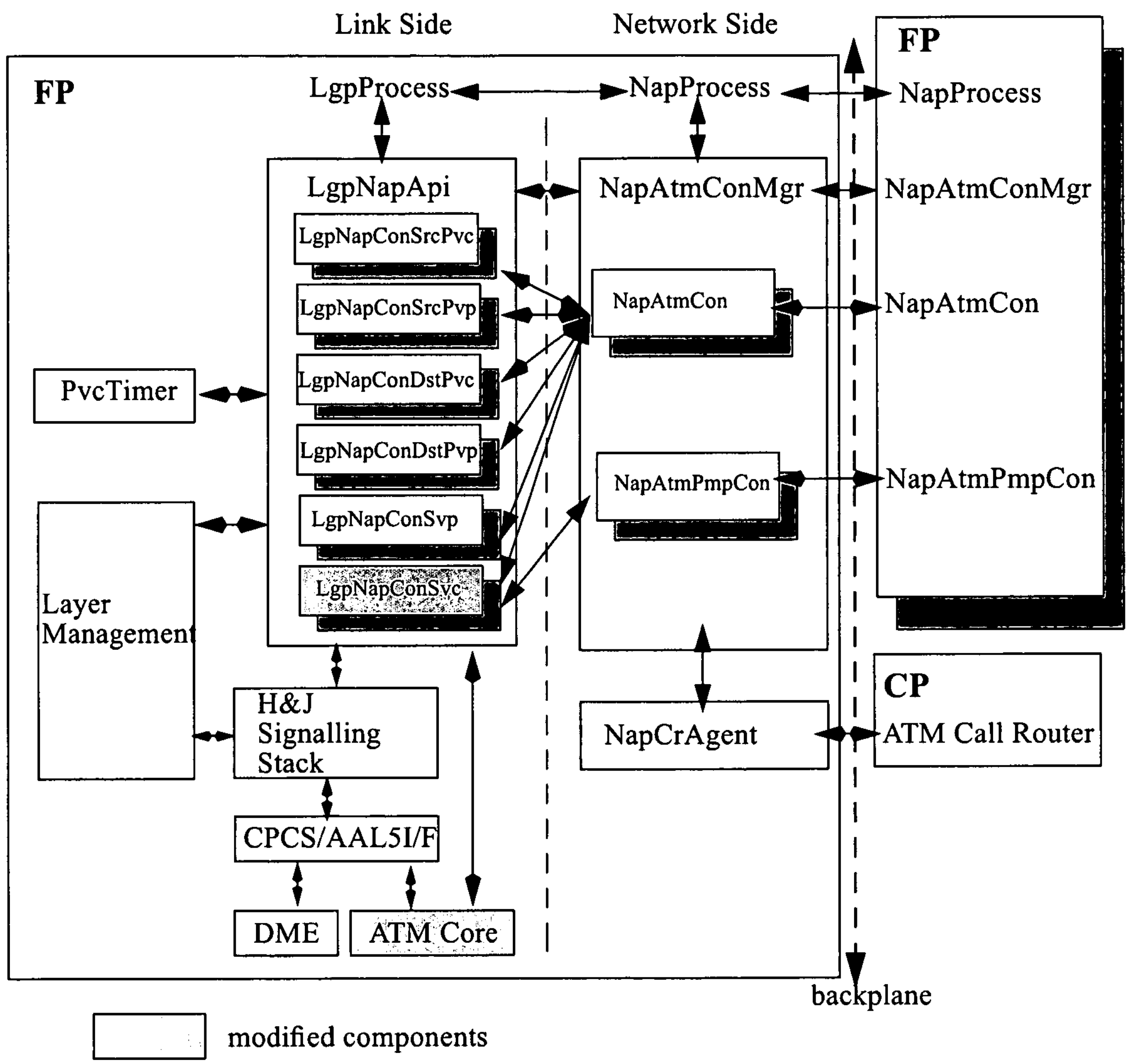
Figure 3 Overview of the MPLS ATM Networking interface to ATM core



3.2.2 ATM Call Control

Figure 4 on page 17 shows the components involved in the ATM Call Control, their relationship and which components need to be modified by this feature.

Figure 4 FP Call Control Architecture

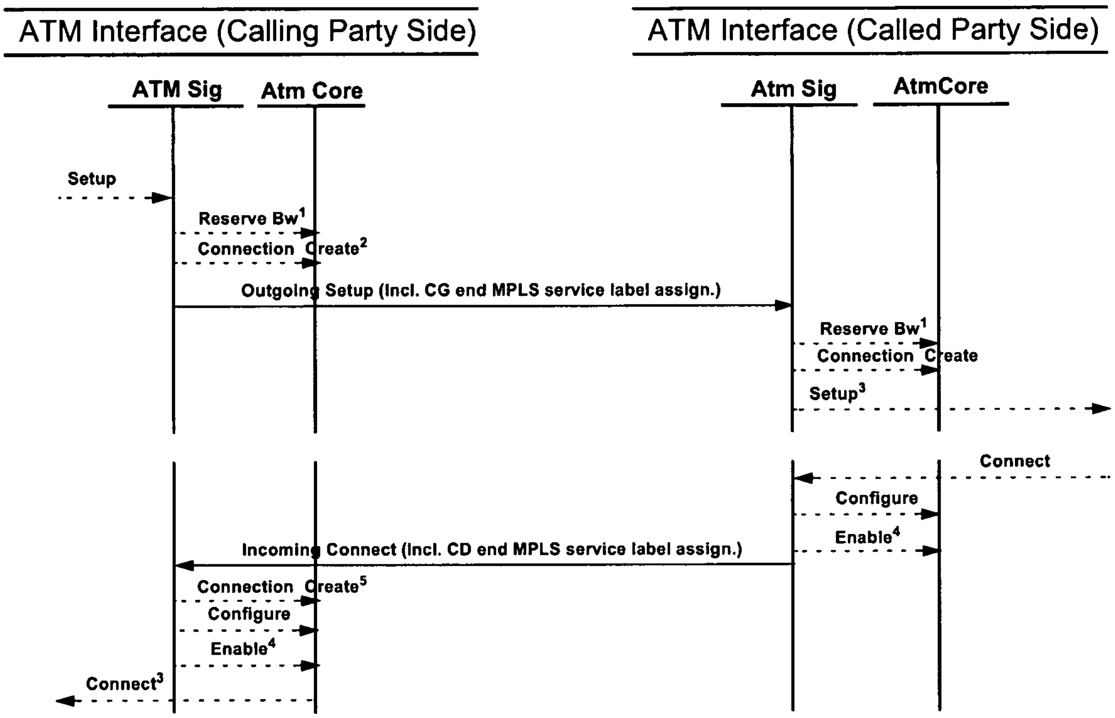


3.3 Information flow

3.3.1 Overview

Figure 5 on page 18 illustrates the ATM Networking message and method sequence in creating on-demand connections over MPLS.

Figure 5 ATM signaling of on-demand connections over MPLS



Note:
[1] MPLS service label assignment provided to ATM Networking along with MPLS transport LSP selection.
[2] Only if VPCI/VCI assignment authority.
[3] MPLS service label assignment removed from PDU.
[4] Datapath bound with remote MPLS service label assignment
5 If not already performed

3.3.2 SETUP arrives on MS3 card entering the MPLS domain

Figure 6 SETUP arrives on MS3 card entering the MPLS domain

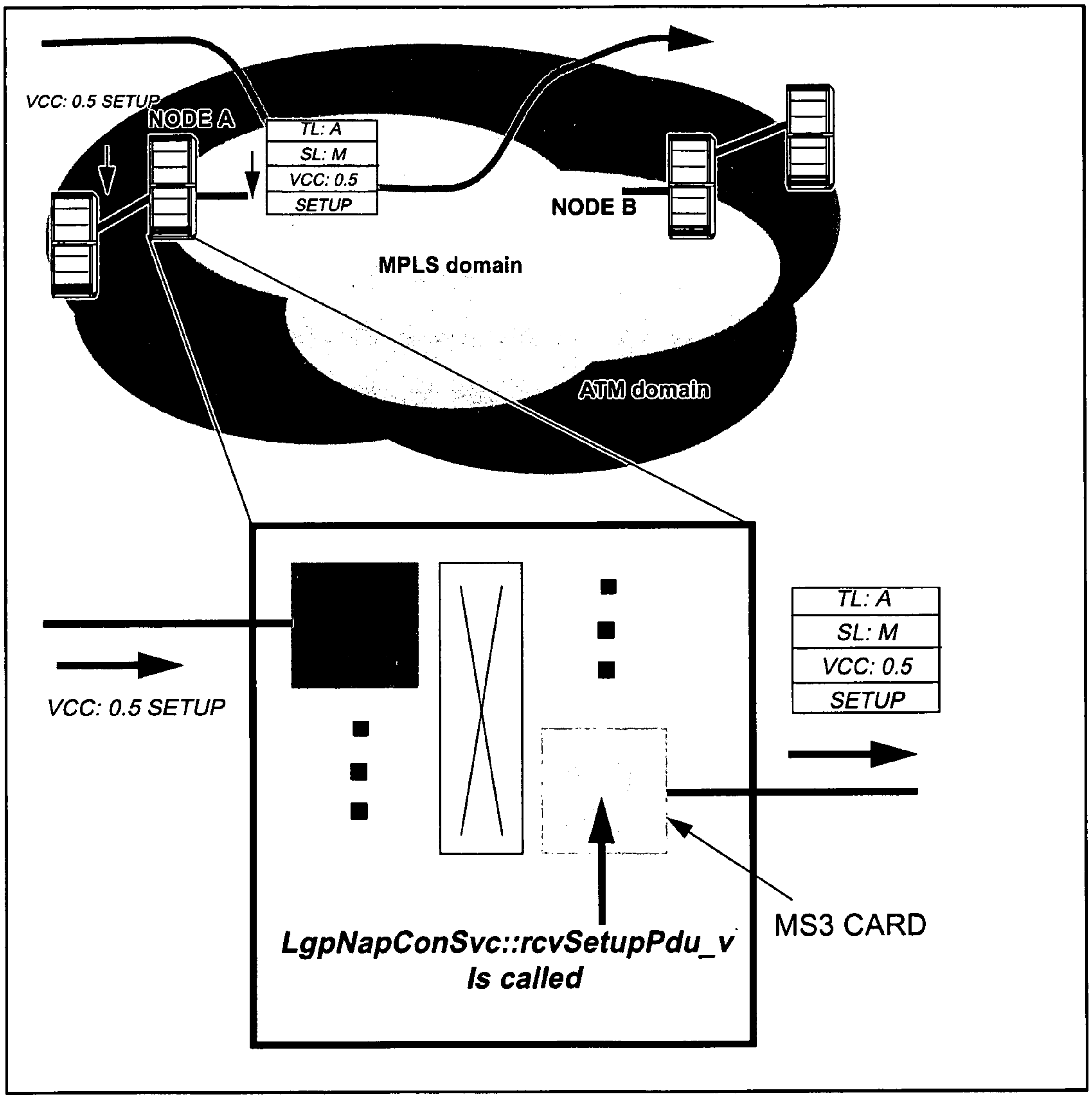
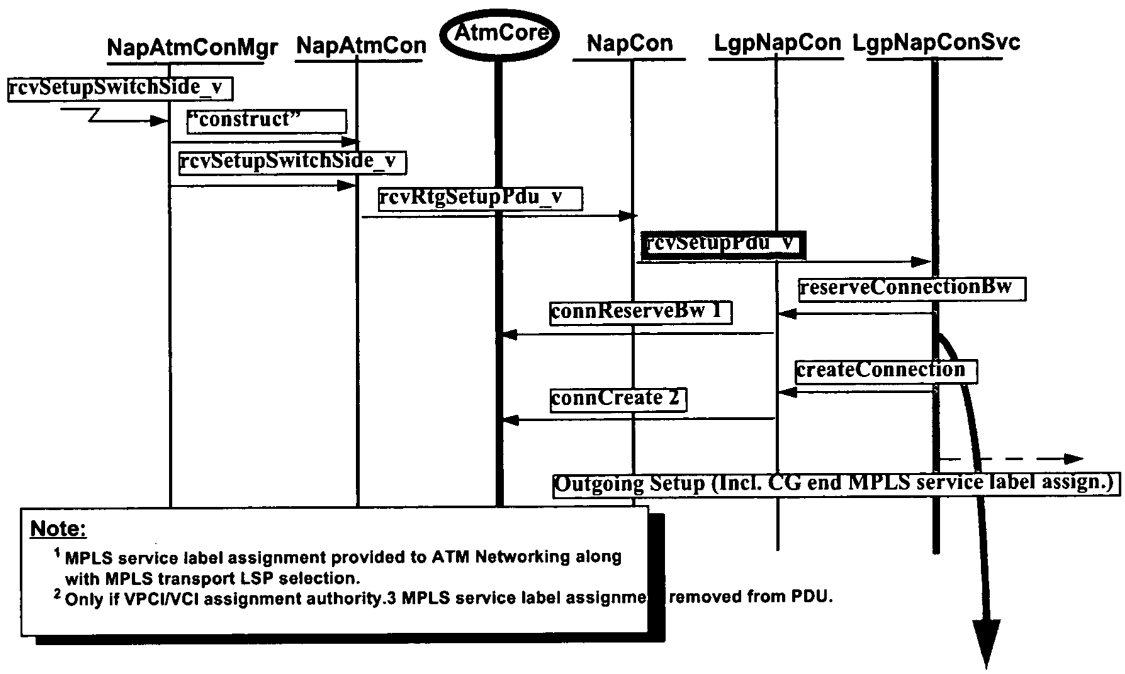


Figure 6 on page 19, shows how, in the case when a SETUP arrives on the MS3 card entering the MPLS domain, the rcvSetupPdu_v method will be called on the LgpNapConSvc object associated with that connection. Figure 7 on page 20 show the message sequence within ATM networking on the MS3 card and the new logic being added to support ATM over MPLS networking.

Figure 7 Message sequence: SETUP arrives on MS3 card entering MPSL domain



LOGIC

- Store the ***local*** MPLS label data received from ATM Core via ReserveBw on the LgpNapConSvc object

IF *(the data received is not NULL)*

THEN

- add a GIT IE to the SETUP PDU Ptr containing this data

ENDIF

3.3.3 SETUP arrives on MS3 card leaving the MPLS domain

Figure 8 SETUP arrives on MS3 card leaving the MPLS domain

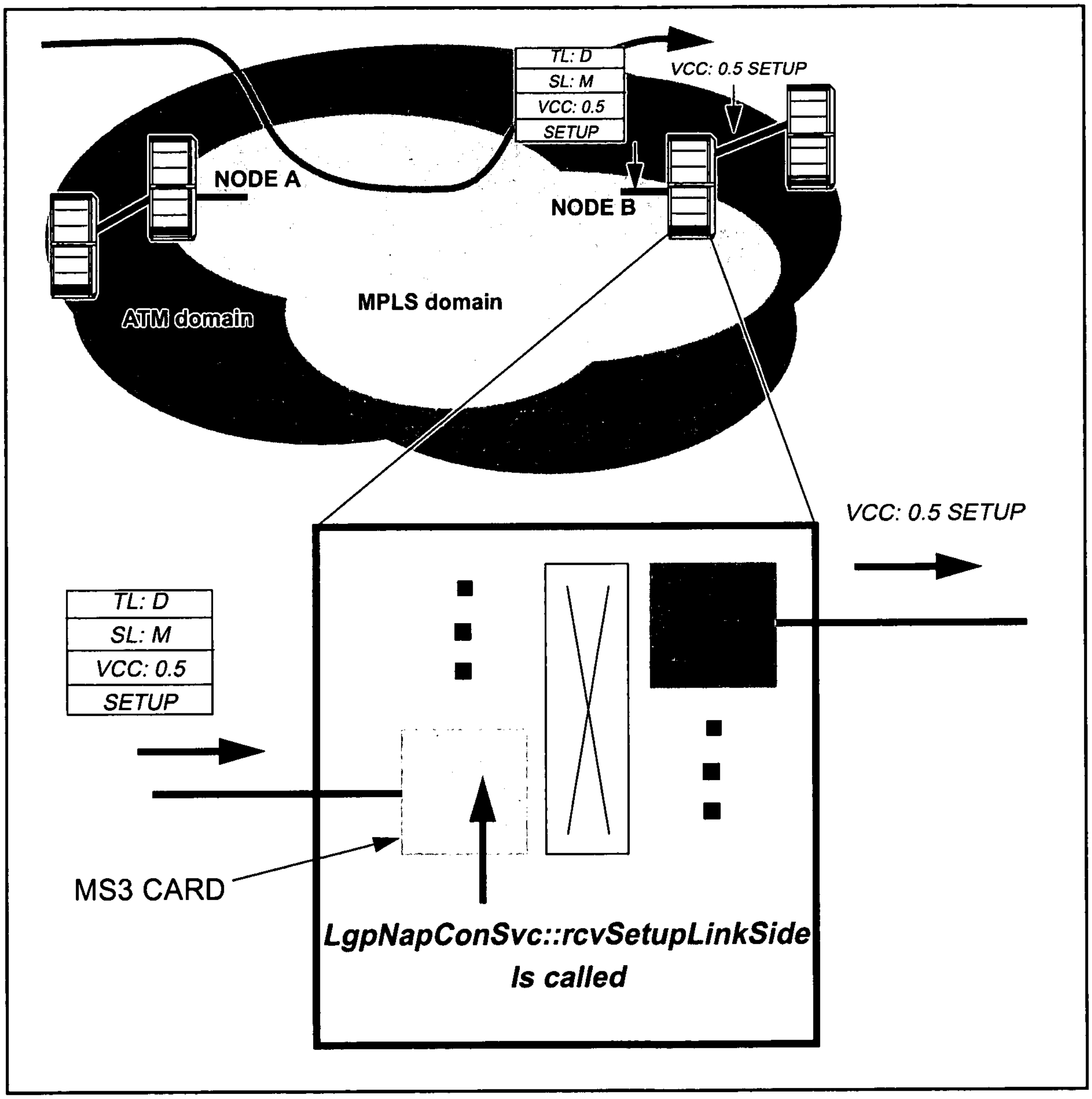
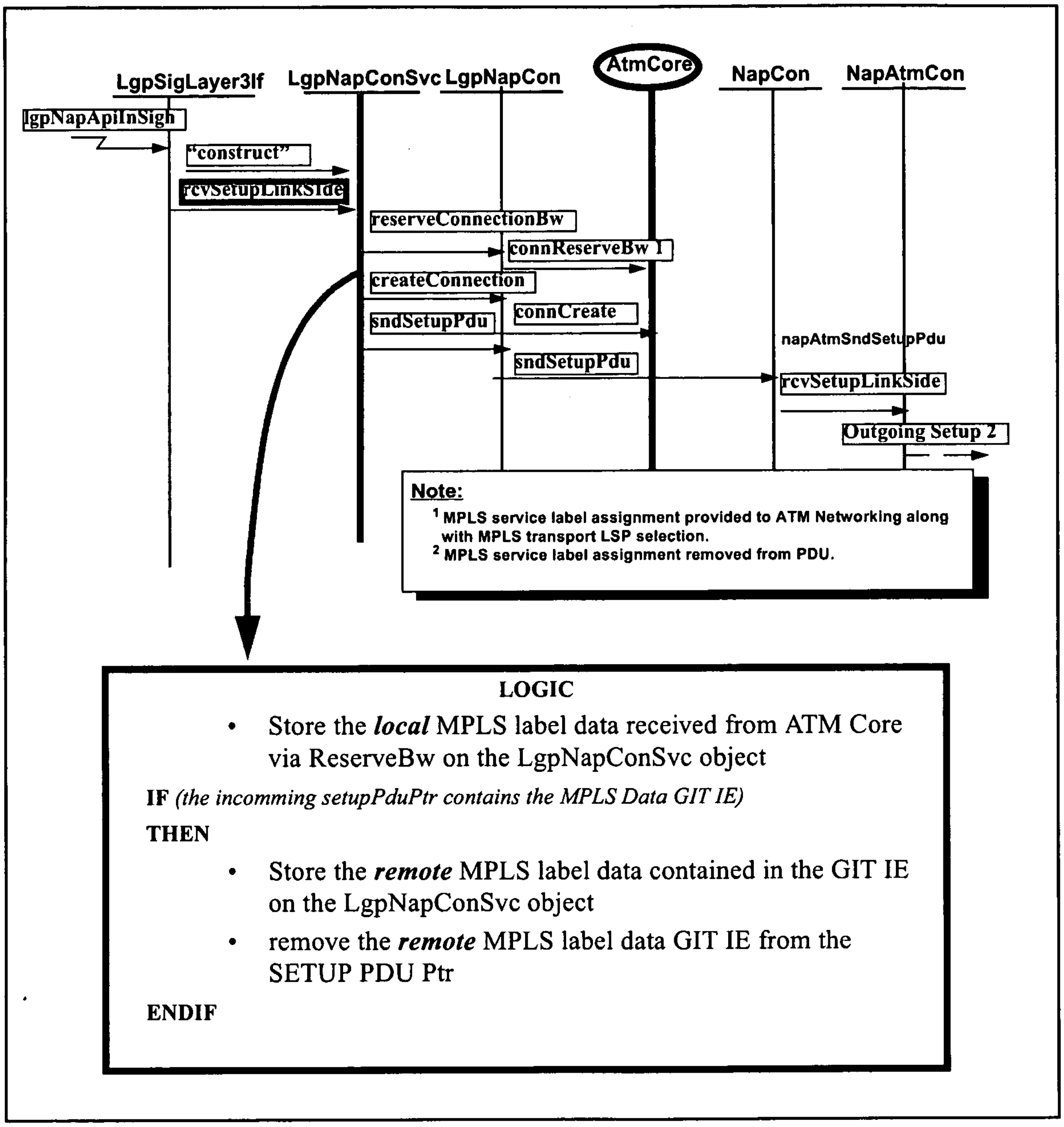


Figure 8 on page 21, shows how, in the case when a SETUP arrives on the MS3 card entering the MPLS domain, the rcvSetupLinkSide method will be called on the LgpNapConSvc object associated with that connection. Figure 9 on page 22 show the message sequence within ATM networking on the MS3 card and the new logic being added to support ATM over MPLS networking.

Figure 9 Message sequence: SETUP arrives on MS3 card leaving the MPLS domain



3.3.4 CONNECT arrives on MS3 card entering the MPLS domain

Figure 10 CONNECT arrives on MS3 card entering the MPLS domain

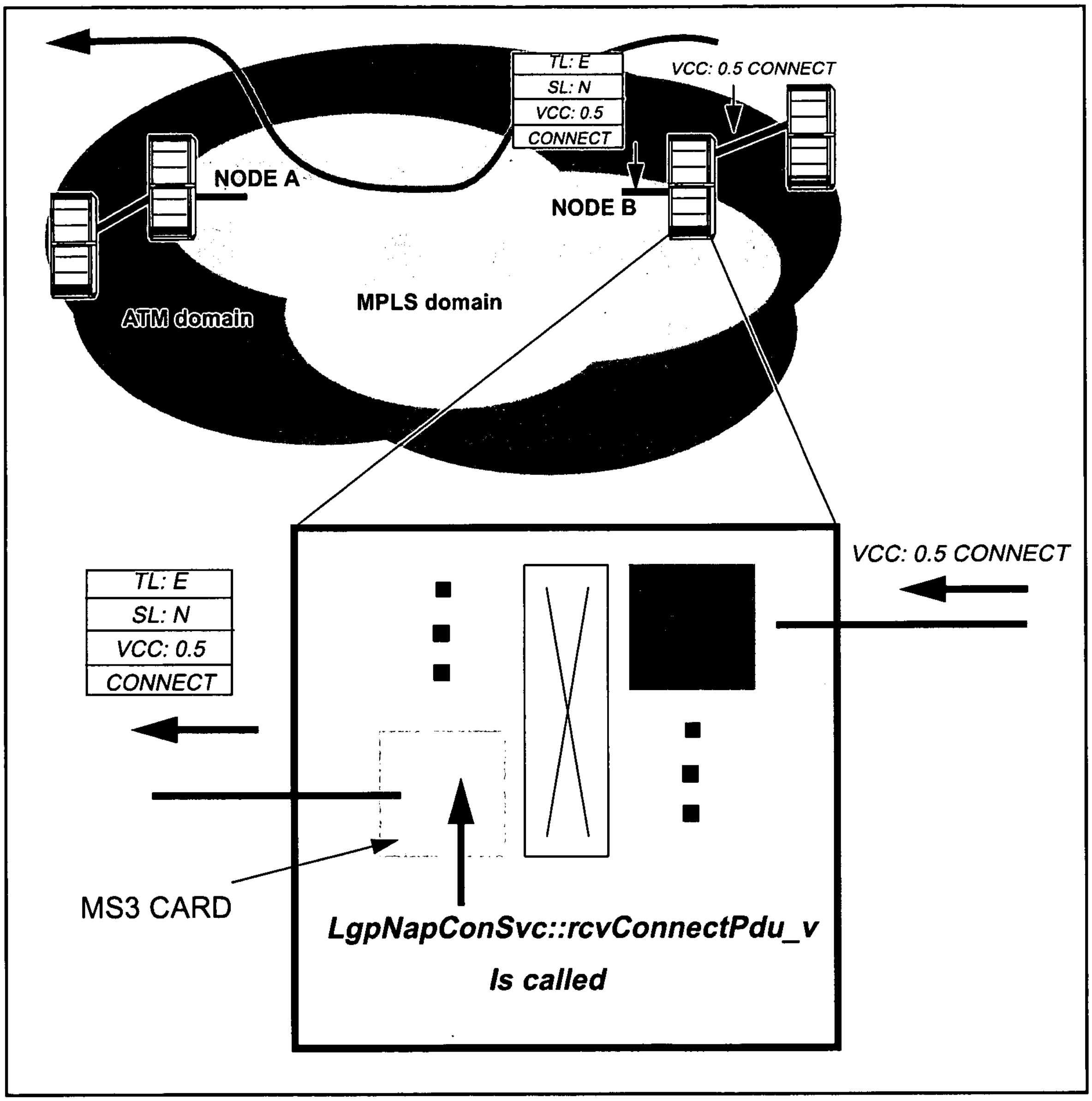
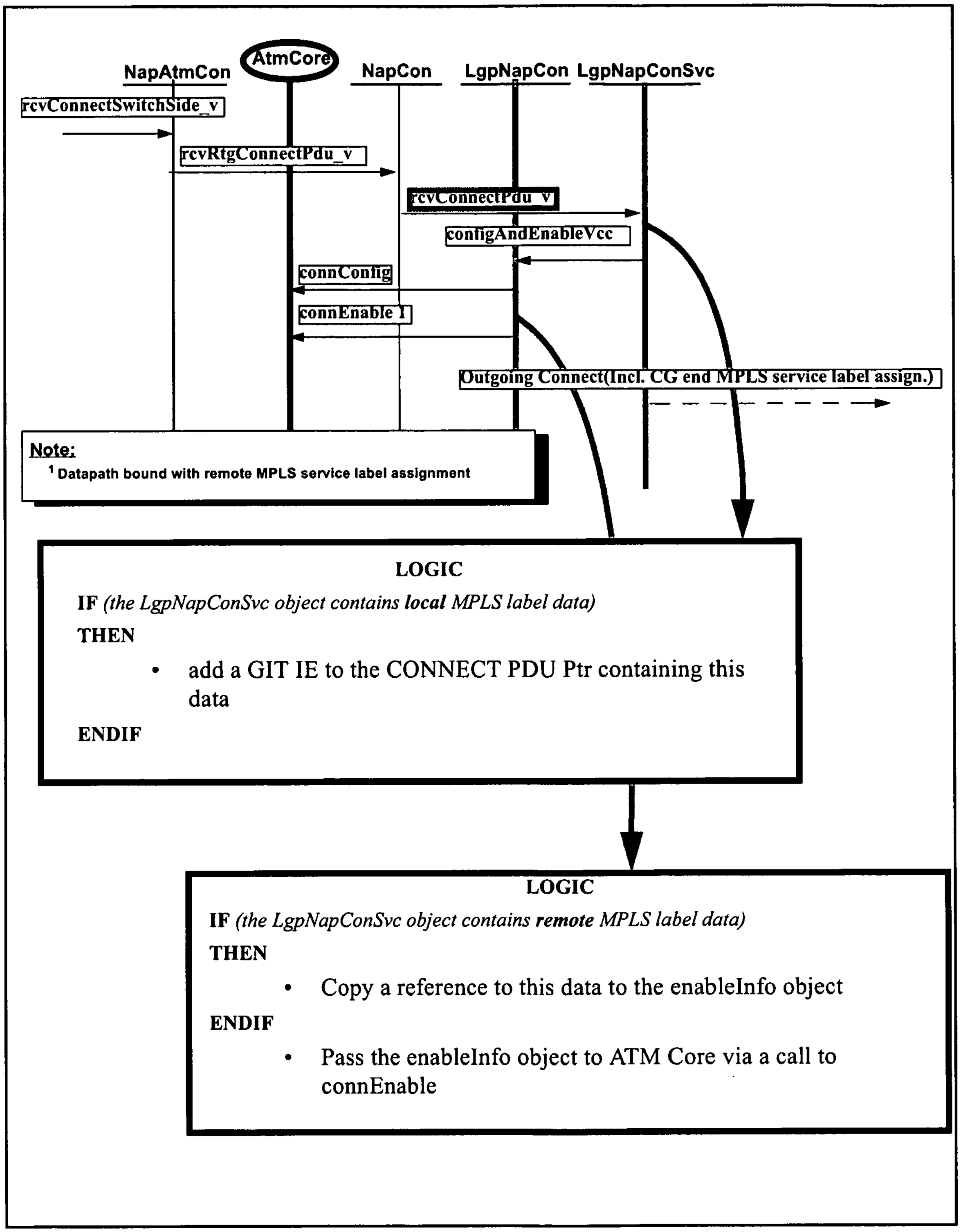


Figure 10 on page 23, shows how, in the case when a SETUP arrives on the MS3 card entering the MPLS domain, the rcvConnectPdu_v method will be called on the LgpNapConSvc object associated with that connection. Figure 11 on page 24 show the message sequence within ATM networking on the MS3 card and the new logic being added to support ATM over MPLS networking.

Figure 11 Message sequence: CONNECT on MS3 card entering the MPLS domain



3.3.5 CONNECT arrives on MS3 card leaving the MPLS domain

Figure 12 CONNECT arrives on MS3 card leaving the MPLS domain

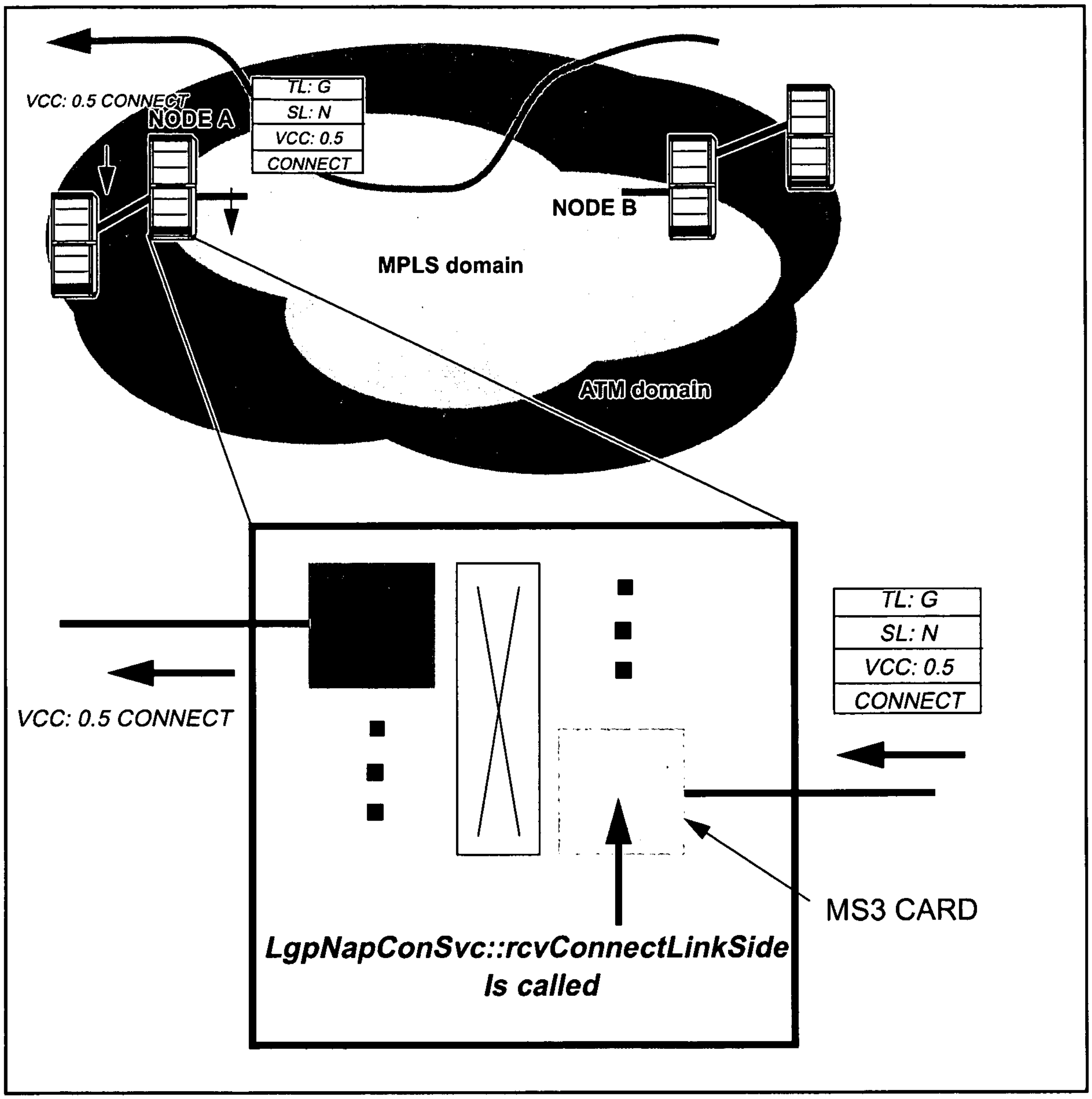
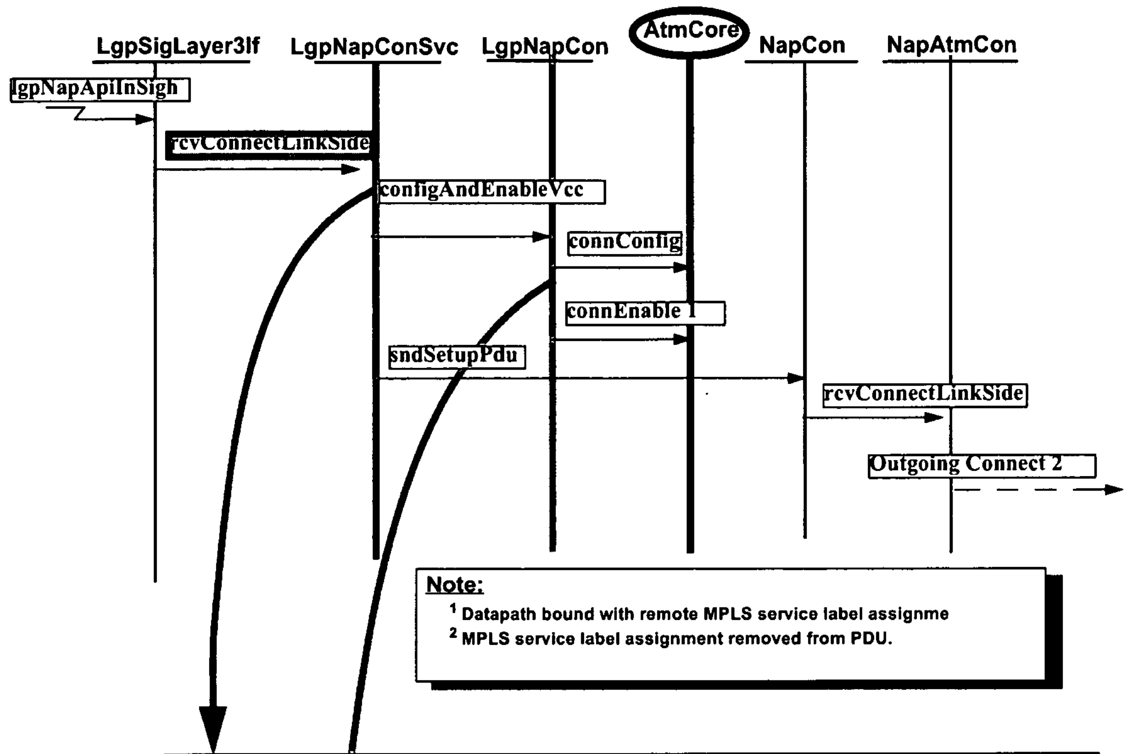


Figure 12 on page 25, shows how, in the case when a SETUP arrives on the MS3 card entering the MPLS domain, the rcvConnectLinkSide method will be called on the LgpNapConSvc object associated with that connection. Figure 13 on page 26 show the message sequence within ATM networking on the MS3 card and the new logic being added to support ATM over MPLS networking.

Figure 13 Message sequence: CONNECT on MS3 card leaving the MPLS domain



LOGIC

IF *(the incomming connectPduPtr contains the MPLS Data GIT IE)*

THEN

- Store the ***remote*** MPLS label data in the GIT IE on the LgpNapConSvc object
- Remove the ***remote*** MPLS label data GIT IE from the CONNECT PDU Ptr

ENDIF

LOGIC

IF *(the LgpNapConSvc object contains **remote** MPLS label data)*

THEN

- Copy a reference to this data to the enableInfo object

ENDIF

- Pass the enableInfo object to ATM Core via a call to connEnable

4 Internal classes and data structures

4.1 Classes and data structures

There is only new class being introduced by this feature is the AtmConnXportData class described below.

4.1.1 Class AtmConnXportData

This class is used to store MPLS label data that is passed to and from ATM core.

4.1.1.1 Class declaration

```
class AtmConnXportData
{
  public :
   AtmConnXportData ();
   AtmConnXportData (const void* data, Uint8 size);
   ~AtmConnXportData ();
   void* getXportData () const;
   void setXportData (const void* data, Uint8 size);
   Uint8  getXportDataSize () const;
  private:
   void*                          xportData_mp;
   Uint8                          xportDataSize_m;
};
```

4.1.2 Class NapGenIdTransIe

The following are new methods which need to be created on the NapGenIdTransIe class. They are used to set and get MPLS data information from the GIT IE.

4.1.2.1 NapGenIdTransIe::setXportData_v(...)

This new method in take the data contained in the AtmConnXportData object and copies it to the MPLS data GIT IE.

- **Inputs**

  `AtmConnXportData* connXportData;`

- **Outputs**

  `VOID`

4.1.3 Class NapGenIdTransIe

4.1.3.1 NapGenIdTransIe::getXportData(...)

This new method populates the AtmConnXportData with the data contained in the MPLS data GIT IE.

- **Inputs**

  `AtmConnXportData* connXportData;`

- **Outputs**

  `Bool`

4.1.4 Class NapPduPtr

The following is a new method which needs to be created on the NapPduPtr as part of this feature.

4.1.4.1 NapPduPtr::getXportGenIdTransIe(...)

This new method will retreive the MPLS data GIT IE and return true if one exists. Otherwise it returns false.

- **Inputs**

  `NapGenIdTransIe&    genIdTransIe;`

- **Outputs**

  `Bool`

5 File organization

Table 1 MODIFIED files

File Name	File Description
atmApiDefs.h	All API related definitions, data structures and types which are used by applications when using the functional API
napPdus.h	Modifications to the NapGenIdTransle Class and the NapPduPtr Class
napPdus.cc	Modifications to the NapGenIdTransle Class and the NapPduPtr Class
lgpNapCon.h	Add new data pointers to the SavedSetupInfo Struct on the LgpNapCon Class
lgpNapCon.cc	Modifications to configAndEnableVcc
lgpNapConSvc.cc	Modify the rcvSetup and rcvConnect methods

Appendix A References

[1] MD-1997.0324, “Passport ATM Networking Phase-2”, SD, Darren Newell et al, July 1999, Nortel Networks.

[2] MD-2000.0422, “CDN Passport MS3/Capacity Evolution ATM Networking”, FS, Andrew Laverance et al, Oct 2000,Nortel Networks.

Appendix B Rejected alternatives

B.1 Design number one

B.1.1 Advantages

B.1.2 Disadvantages

B.1.3 Reasons for rejection

Index

Invention Disclosure Submission Reply

Disc No:		Received Date:	28 mar 2001
Disclosure Title:	Asynchronous Transfer Mode over Multi-Protocol Label Switching Control Plane Connection Establishment Mechanism		

COPY

---=== Inventors ===---

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---=== Attachments ===---

File Name	File Type	File Comments
ATM_Networking_over_MPLS_FS	PDF (Adobe)	Section 4 is composed of the External Description and provides details on the intent and implementation of ATM on-demand connections over MPLS. Section 5 provides networking scenarios
ATM_Networking_over_MPLS_SD	PDF (Adobe)	Section 3 contains the Overall description which describes in detail how ATM on-demand connections are established over an MPLS network.
Nortel_contribution_April	Microsoft Word (*.doc)	Nortel Standards contribution for ATM Forum mtg April 22-27/2001

General_Requirements_for_ATM-MPLS_Interworking	PDF (Adobe)	ATM Forum January/2001: Describes a framework and requirements for ATM/MPLS interworking, but does not describe how this is accomplished.

<End of Attachments>

Were there additional inventors involved:	yes	**Was there contractor involvement**	
Name of Supervisor or Divisional Head:		**Name of VP:**	
LOB:		**Business Unit:**	
Conception Date:			

Has this invention been discussed with others? If so, please complete:

Inside Nortel - Whom?		**Outside Nortel - Whom?**	
Inside Nortel - When?		**Outside Nortel - When?**	
NDA?	yes		

Are you aware of any imminent future disclosures? Please provide dates and details:

April 22-27, 2001 limited disclosure at ATM Forum technical mtg.

Keywords for Searching:	**Products that will use this invention:**

Does this invention arise from any arrangement involving an external organization?

Is this invention relevant to a Standards Activity?	**Internal Funding Project #'s:**
yes	

If so, give details:

THIS INVENTION IS BEING DISCLOSED IN THE ATM FORUM STANDARDS GROUP IN APRIL.

As the standardization plan is to disclose this invention to another company to gain support in the standards body, I would appreciate some advice
New standards contribution being developed within both the ATM Forum in April/2001 and ITU-T in May/2001 to address ATM over MPLS on-demand connection establishment.

The proposed Nortel standards contribution to be submitted to the April ATM Forum mtg is attached

Technical Information

Brief Description of the Invention:

This invention provides a mechanism to allow the call establishment of ATM connections over a lower layer non-ATM connection-oriented media through the utilization of ATM signaling protocols to exchange lower layer transfer plane information.

A typical use of this invention is to allow the establishment of ATM connections over an MPLS transport media using ATM signaling to convey MPLS transfer plane information.

ATM Networking over MPLS design documentation is attached.

Problem Solved by the Invention:

Through the use of ATM signaling protocols, lower layer connections can be established with ATM call establishment procedures to allow a faster and more efficient mechanism for tunneling ATM on-demand connections through an MPLS network.

Solutions that have been tried and why they didn't work:

Potential solutions involve the coordination of MPLS and ATM control planes, but the coordination of 2 separate control planes and signaling protocols are more complex and less efficient than the proposal discussed in this invention disclosure.

Specific elements or steps that solved the problem and how they do it:

Currently there are no call control procedures for the establishment and clearing of ATM on-demand connections over MPLS. This invention proposes a solution to the establishment and clearing of ATM connections over an MPLS network. The invention presented can also be extended to incorporate ATM call control procedures over a connection-oriented media.

An MPLS network consists of MPLS switches serving as Label Edge Routers (LERs) and Label Switched Routers (LSRs) and provide connection services for the establishment of MPLS connections. To allow ATM connections to traverse an MPLS network, ATM connection information needs to be exchanged between its call control peers. In ATM networks, ATM signaling protocols are used to exchange ATM connection context between its call control peers. To allow on-demand ATM connection services an ATM signaling channel needs to be configured through an MPLS 'transport' connection between call control peers. Once established, this invention allows ATM connections to be established and cleared within the same MPLS 'transport' connection using MPLS label stacking to identify individual ATM connections as MPLS 'service' connections. This mechanism allows ATM connections to be established, maintained and cleared across an MPLS network without intervention from MPLS signaling protocols (e.g. RSVP, CR-LDP).

To achieve this, the exchange of transfer plane information (e.g. MPLS label reservations) for individual MPLS 'service' connections associated with each individual ATM connection is conveyed within existing ATM signaling PDUs (i.e. SETUP and CONNECT PDUs). Once MPLS transfer plane information is exchanged between ATM signaling peers the MPLS 'service' context is configure in hardware to allow bi-directional tunneling of ATM traffic through an MPLS network.

Commercial value of the invention to Nortel and Nortel's major competitors:

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